The effective use of interactive multimedia in education: Design and implementation issues

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Many interactive multimedia programs today are designed as self contained learning packages which visualise the learners as individuals, working independently and privately. In this scenario, teachers are essentially redundant to the learning process, relegated to the role of 'course managers'. However, research derived from new learning theory is clearly showing that multimedia has brought us no closer to the 'goodbye teacher' syndrome exemplified by Keller in his famous article on individualised instruction in 1968. The role of the teacher is fundamental to the effective use of interactive multimedia.

This paper will examine the design of interactive multimedia from the perspective of situated learning, and discuss the critical characteristics that are present in learning environments designed using this theory The role of the teacher, and the importance of allowing for collaboration between teachers and learners will be discussed The paper will argue that even the best interactive multimedia programs can be used ineffectively without thought to appropriate conditions of implementation in the classroom.

Goodbye teacher

Keller's ironically titled paper of 1968, 'Goodbye teacher...' directly addressed the concerns of educators of the time, who were apprehensive about the changing role of the teacher with the introduction of teaching machines and individualised instruction. There was widespread concern that the teacher would be a casualty of the new technologies and approaches (Keller, 1968).

Recent years have seen a rapid increase in the level and scope of multimedia materials being used for instructional purposes in universities and schools. While computers have been used to support instruction and training for many years, it was not until the multimedia capability arrived that university teaching started to take an active interest in using computer based technologies in support of program delivery. Today, there are few universities in Australia where there is not an established support unit that actively promotes the use of multimedia and interactive technologies as a means to improve teaching and learning.

One of the main forces driving the creation of computer based instructional materials using multimedia technologies has been the move to more fully develop the potential of open learning in university teaching. Open learning describes a learning environment with a reduced level of teacher centred instruction. The core to open learning is the use of flexible modes of delivery of the instructional content. Open learning requires the development and use of teaching resources to significantly reduce the level of face to face teaching and learning. Multimedia materials appear to have strong potential for this application and are seen as one of the most effective delivery media for this purpose. They provide the means to create stimulating and interactive teaching and learning episodes with computer technology delivery. High levels of learner control and interactivity are seen as critical elements in the creation of effective multimedia programs.

Much of the design of interactive multimedia learning materials is now towards the development of materials for the independent learner. There is an implicit expectation and assumption that students can learn effectively and efficiently from independent interactions with the computer based materials. These expectations are drawn from theories of learning and cognitive development that are based on quite narrow and individualistic definitions of learning (cf. Resnick, 1987a). There is now a growing body of research that has begun to explore learning and cognitive development from a cultural perspective by considering social influences within learning domains (eg., Newman, Griffin, & Cole, 1989; Mercer & Fisher, 1993). The outcomes from this research strongly support contentions that learning with computers can be considerably enhanced through applications where communicative and social factors are included as integral components of the instruction.

Many teachers and instructors, and software designers, hold the naive view that the nature of the learning achieved through the use of multimedia programs is defined by the software itself. People ascribe measures of goodness to particular items of software based on their perceptions of the quality of the teaching and learning it can support. It is becoming increasingly evident that while the software influences the learning, principal elements in determining the quality of the learning are the social, communicative and teacher support factors that accompany use of the program. Individual use minimises many of the advantages that may be gained from these factors. When the teacher acts as coach in a learning environment supported by computers, the extra dimensions described above can be more easily gained.

Like Keller's individualised learning system, most educational software and multimedia products have been influenced more by theories of learning which have been concerned with individualised representations of learning, rather than learning as a social, culturally based process (Mercer & Fisher, 1992). One recent learning theory which acknowledges and promotes the social and collaborative nature of learning, and has implications for the design and implementation of interactive multimedia, is that of situated learning (Brown, Collins and Duguid, 1989b).

Situated learning

Before the invention of schools, nearly all formal and skill based knowledge was transferred through apprenticeships (Collins, 1988). Agricultural skills, trades, medicine, law and the arts were all taught within the context of the skills of the master being handed on to the apprentice (Collins, Brown, & Newman, 1989). The concept of the apprentice as learner captured the imaginations of theorists and researchers in the mid to late 1980s. According to Lave and Wenger (1991), the term *apprenticeship* was used extensively in discussions and arguments about the nature of learning. 'Apprenticeship had become yet another panacea for a broad spectrum of learning-research problems, and was in danger of becoming meaningless' (p.30).

However, Brown, Collins and Duguid (1989b) in their theory of *situated learning,* attempted to distinguish and define those aspects of apprenticeships which were critical to the success of learning. Their aim was to begin the process of developing a theoretical perspective for successful learning that cognitive science had, to date, not been able to explain:

One of our goals is to try to understand what underlies successful learning and to try to produce better methods of teaching. Apprenticeship and related learning methods seem particularly successful, but standard cognitive theory is inadequate for explaining the success. (Brown, Collins, & Duguid, 1989a, p.12).

Collins (1988) defines situated learning as: 'the notion of learning knowledge and skills in contexts that reflect the way the knowledge will be useful in real life' (p. 2). As such, situated learning has implications not only for classroom practice, but also for the design of interactive multimedia.

The critical elements of situated learning

What are the characteristics or critical elements of situated learning and how does this theory help in our understanding of interactive multimedia and its implementation in learning contexts? McLellan (1994) summarises the key components of the situated learning model as: apprenticeship, collaboration, reflection, coaching, multiple practice, and articulation of learning skills (p. 7). However, the recent contributions of various theorists and researchers, including the original authors of the model, have expanded and refined the notion to a much more comprehensive and far reaching framework for classroom application.

A critical reading of the principal theorists of situated learning (eg., Brown, et al., 1989b; Brown & Duguid, 1993; Collins, et al., 1989; Young, 1993; Cognition & Technology Group at Vanderbilt (CTGV), 1990, 1993a, 1993b, 1993c; Lave & Wenger, 1991; Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; Resnick, 1987b) reveals a number of important characteristics which have added to the evolving theory of situated learning (Herrington & Oliver, 1995).

Many of these authors and theorists believe that useable knowledge is best gained in learning environments which feature the following characteristics:

Authentic context. A situated learning environment provides an authentic context that reflects the way the knowledge will be used in real life, that preserves the full context of the situation without fragmentation and decomposition, that invites exploration and allows for the natural complexity of the real world.

Authentic activities. A situated learning environment also provides authentic activities which are ill defined - students find as well as solve the problems. It is an environment where tasks can be integrated across subject areas, and it provides the opportunity to detect relevant and irrelevant material.

Expert performance. Situated learning environments provide access to expert performances and the modelling of processes, allowing students to observe the task before it is attempted. Such access enables narratives and stories to be accumulated, and invites the learner to absorb strategies which employ the social periphery (legitimate peripheral participation).

Multiple roles and perspectives. The learner is provided with the opportunity to investigate multiple roles and perspectives.

Collaboration. A situated learning environment supports the collaborative construction of knowledge.

Coaching and scaffolding. The learning environment provides for coaching at critical times, and scaffolding of support, where the teacher provides the skills, strategies and links that the students are unable to provide to complete the task. Gradually, the support (the scaffolding) is removed until the student is able to stand alone.

Reflection. Situated learning environments promotes reflection to enable abstractions to be formed.

Articulation. A situated learning environment promotes articulation to enable tacit knowledge to be made explicit.

Integrated assessment. A situated learning environment provides for integrated assessment of learning within the tasks.

Applying the critical characteristics to the design and implementation of interactive multimedia

In the development of the theory of situated learning, there has been much debate about whether a situated learning approach could be transferred to a computer based learning environment. Indeed, some writers dispute that it can even be classroom based on the grounds that students are not exposed to real life situations (eg., Tripp, 1993; Hummel, 1993).

However, many of those exploring the model of situated learning have accepted that the computer has provided an alternative to the real life apprenticeship system, and that it may be possible to capture those successful elements and transfer them to computer based situations. McLellan (1994) sums up these approaches by pointing out that while knowledge must be learned in context according to the situated learning model, that context can be: 'the actual work setting, highly realistic or 'virtual' surrogate of the actual work environment, or an anchoring context such as a video or multimedia program' (p. 8).

In terms of the instructional design of interactive multimedia, the critical characteristics of situated learning can be examined within a framework of the roles and responsibilities of three mutually constitutive elements of the learning process: *the learner, the implementation* and *the interactive multimedia program* (Figure 1) (Herrington & Oliver, 1995).

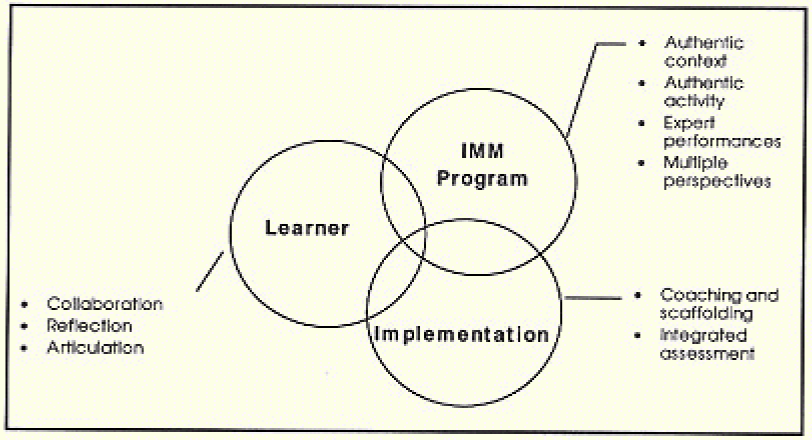

Figure 1: Constitutive elements of situated learning in interactive multimedia

Using this framework to evaluate interactive multimedia, it can be seen that many effectively designed programs do incorporate authentic contexts and activities, and account for multiple perspectives and expert performance. However, in designing for the role of the *learner* and the *implementation* of the program in the learning situation, even the best programs are inadequate to meet the demands placed upon them if it is assumed the program itself can fulfil *all* the needs of the learner. In such programs, two elements of the situated learning model are frequently neglected: collaboration, and coaching and scaffolding.

Collaboration

For many years, distance educators have investigated and refined the use of computer and communication technologies to solve the paramount problem of the distant learner: isolation. Audio conferencing, video conferencing, audiographics and live interactive television have been used to provide external students with the opportunity to share ideas and negotiate meaning in synchronous interactions. The high cost of implementing these technologies has been balanced by the perceived benefits of teacher-student and student-student collaboration (Latchem, Walsh, & Grant, 1993).

However, the inherent social benefits of on campus learning are often neglected by lecturers intent upon students using multimedia programs individually in non-contact time in computer labs, in libraries and increasingly in their own homes and workplaces. The collaborative opportunities so eagerly sought by distance educators are discarded or overlooked in the belief that the interactive multimedia program can meet all the learner's needs.

For those lecturers who do use the interactive multimedia programs in timetabled classes, it is often the case that the continuing scarcity of resources in education means that students are required to share computers (Chipman, 1993). Group use of computers does not, however, guarantee collaboration. Katz and Lesgold (1993) point out that collaboration is more than cooperation: 'Cooperation ... involves a division of labour in achieving a task. Collaboration happens synchronously; cooperation is either synchronous or asynchronous' (p. 289). Roschelle and Behrend define collaboration as: 'the mutual engagement of participants in a coordinated effort to solve a problem together' (Roschelle & Behrend, 1993, cited in Katz & Lesgold, 1993, p. 289). Jonassen's (1995) discussion of collaboration also emphasises learners' social roles in 'exploiting each other's skills while providing social support and modelling and observing the contributions of each member' (p.60). Forman and Cazden take this definition even further by suggesting that true collaboration is not simply working together but also 'solving a problem or creating a product which could not have been completed independently' (Forman & Cazden, 1985, cited in Repman, Weller, & Lan, 1993, p. 286).

Research to date has shown that the use of computers per se has a tendency to promote cooperation and collaboration among students and their teachers. Dwyer (1995) reports that in the *Apple Classroom of Tomorrow* (ACOT) study there was a dramatic decrease in teacher led activities and a corresponding increase in cooperative activities. Collins (1991) lists increased cooperation as one of eight major trends observed in schools that have adopted computers.

While there is some support for the notion that computers can provide a useful means to enhance individual 'personalised' knowledge (Ambrose, 1991; Nelson & Palumbo, 1992), a recent evaluation of 60 cooperative learning research studies found that 72% of the studies reported positive outcomes for cooperative activities, while only 8% reported positive outcomes for non-cooperative activities (Slavin, 1989 cited in Repman, et al., 1993). Qin, Johnson and Johnson's (1995) meta-analysis of 63 studies of higher order learning and problem solving found that cooperative efforts resulted in better problem solving than competitive efforts (in 55, cooperation outperformed competition; in 8, competition outperformed cooperation). Other studies (see Del Marie Rysavy & Sales, 1991) have shown that there are clear educational advantages to be derived from collaboration between students who are required to predict and hypothesise, and then suggest a solution. In order to promote collaborative learning with interactive multimedia, both designers and implementers need to consider ways to maximise the opportunities for learners to collaborate.

Guidelines to promote collaboration

Some implications of providing for collaboration within a situated learning framework for the *designer* of the interactive multimedia program are:

1. Provide activities and problems to be solved that are consistent with group work.
2. Avoid low level responses that do not require group discussion or the construction of a considered response.
3. Provide complex activities and problems which cannot be solved simply by recollecting factual information presented in another part of the program.

Implications for the *teacher* implementing the program:

1. Use complex problems provided by the program itself, or design your own activities which place the problem into a real world context.
2. Ensure students work in pairs or small groups.
3. Design activities for students using the interactive multimedia program which enables each participant to contribute a unique function or role to the task.
4. Assist students to design their own investigations using the interactive multimedia program as a resource.

Coaching and scaffolding

Teachers and lecturers who send students off individually to work on interactive multimedia programs are not only denying them the benefits of collaboration, but possibly also the benefits of expert assistance - providing hints, suggestions, critical questions, and the 'scaffolding' to enable them to solve more complex problems.

Some argue that the interactive multimedia program itself can fulfil the coaching role, and some programs are designed to 'eliminate pedagogical roles for teachers', to effectively make them 'teacher proof' (Reeves, 1993). There have been some attempts to design interactive multimedia and computer based instruction which provides inbuilt coaching in certain learning situations (see Collins, 1988; Young, 1995). Lajoie (1993) describes a computer based environment for avionics troubleshooting entitled Sherlock 1 which is designed to provide coaching:

> Sherlock [coaches] the learner in the context of the problem when assistance is required or requested... Sherlock is designed to offer the least hint that can enable further problem solving progress. Much of its coaching is designed to stimulate a trainee's thinking by asking questions rather than generating answers. However, when a trainee can not construct an answer on her own, more elaborate hints are available that support the trainee's problem solving much as a shop supervisor might. (Lajoie, 1993, p. 265-266}

Such computer based coaching is promising, but would require extremely sophisticated programming techniques for effective support to be offered in the complex learning environments envisaged by proponents of situated learning. Efforts to date have generally resulted in 'fairly crude approximations of the complex, subtle behaviours exhibited by human tutors' (Wilson & Welsh, 1991, p. 7). Collins et al. (1989) point out that coaching is highly situation-specific and is related to problems that arise as students attempt to integrate skills and knowledge, a role that is still best performed by the teacher.

Coaching in a situated learning environment requires a radically different approach. Especially when associated with the use of interactive multimedia, such environments require 'powerful, but different roles for teachers' (Choi, 1995, p. 67). Collins (1991) draws an analogy with the piano teacher: 'The third party, the computer ... encourages the teacher to play the role of a coach, in much the same way that a piano encourages the teacher to play the role of a coach in the piano lesson' (p. 29). However, Jonassen (1993) points out that unless the teacher initiates such a change in approach, students may continue to use interactive multimedia programs in the same low level manner they use books, browsing for factual information: 'Knowledge construction usually accedes to reproduction. Typically, there is only one perspective worth memorising - the teacher's - because that is what will be tested. Teachers find it difficult to give up control' (p. 37).

What is expected of the teacher in implementing an interactive multimedia program? A useful analysis is to list three essentially different, but frequently observed, approaches, and compare each role with a number of dimensions in the use of interactive multimedia. Table 1 shows examples of the types of roles adopted by teachers, typically in tertiary institutions, in using interactive multimedia in the classroom: teacher as transmitter of knowledge, teacher as coach, and teacher as manager.

Table 1: Three roles of the teacher in the use of interactive multimedia

Dimension of IMM	**Teacher as ...**		
	Transmitter	**Manager**	**Coach**
Time	Timetabled lecture time	Students' own time	Timetabled lecture time and students' own time
Place	Classroom or lecture theatre	Lab, library, student's home	Classroom or computer lab
Size of groups	Whole class	Individuals	Small groups
Activities	Question and answer	Teacher or program designed problems	Student designed investigations
Teaching strategy	Teacher operates the IMM program projected at the front of the class while students watch	Teacher asks students to work with the IMM program individually in their own time	Teacher moves around class providing assistance as students work on IMM program
Teacher activity	Demonstrating, presenting information	Monitoring progress, record keeping, trouble shooting, removing impediments to progress	Providing 'scaffolding', aiding students' inquiries
Students' cognitive activity	Listening, writing notes	Reading, completing activities	Reflecting, analysing, planning, problem solving, collaborating
Potential learning outcomes	Memorisation of knowledge, factual recall	Knowledge, comprehension	Understanding, higher order learning, transfer

The intention here is not to suggest that all teachers should adopt the role of coach at all times with every use of interactive multimedia. Each position has its own strengths and these should be exploited. The transmitter role is an excellent mode for modelling the use of a complex program. The manager role is one which encourages self directed learning and is increasingly useful in universities that are seeking to blur the distinction between internal and external modes of delivery; indeed, many universities are predicating their reforms in the area of reduced contact time on the very notion of alternative delivery modes and new approaches to managing students.

The point we are making is that the teacher as coach is a fundamental and integral part of the process of using interactive multimedia effectively, and should not be overlooked. How can the role of the teacher as coach be promoted in the design and implementation of programs?

Guidelines to promote coaching by the teacher

Some implications of providing for the role of the teacher within a situated learning framework for the *designer* of the interactive multimedia program are:

1. Design programs which avoid step by step instruction in favour of complex, open ended learning environments.
2. Allow a role for the teacher; don't assume that all feedback and assistance must be implicit in the program
3. Somewhere in the package, provide flexible suggestions and guidelines to address the needs of the teacher who may wish to optimise the use of the program in a variety of different contexts.

Implications for the *teacher* implementing the program:

1. Be thoroughly familiar with the program and its possibilities.
2. Be available to students when they are using the program.
3. Provide assistance to students as they use the program, not by supplying the solution if there is one, but by giving just enough guidance - the 'scaffolding' - to take them to the next stage.

Conclusion

Multimedia has a significant future in education. The body of research accompanying its continual development is aiding considerably in improving the effectiveness of these technologies as a delivery medium. As a new medium, some of the instructional design that accompanies materials development is pioneering and innovative.

The purpose of this paper is to focus attention on some design strategies that have the prospect to considerably enhance outcomes achieved through multimedia applications. In particular, the paper shows the value to be gained from considering implementation strategies as part of the design process.

The quality of instructional materials cannot be considered independently of the manner in which they are used. There are many advantages to be gained from implementing instructional materials of any form in a manner which creates collaborative learning environments and provides forms of scaffolding to support the construction of knowledge. Too many times we consider that multimedia materials are best designed and implemented as independent instruction for individual learners. This paper has proposed that when designers consider multimedia as one aspect of a greater learning environment that also encompasses learners and teachers, the quality and quantity of the learning that can be achieved is significantly enhanced.

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